INTELLIGENT MUSIC APPLICATIONS: INNOVATIVE SOLUTIONS FOR MUSICIANS AND LISTENERS

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ABSTRACT

The incorporation of artificial intelligence and machine learning into intelligent music applications presents fresh avenues for musical expression. These applications allow the production of emotionally responsive pieces by analysing and interpreting the emotions conveyed within music. Furthermore, they aid collaborative music-making by connecting musicians in diverse locations and enabling real-time collaboration via cloud-based platforms. The objective of this research is to present information regarding the production, distribution, and consumption of music, which has a close association with technology. Through document analysis, the prospective advantages of incorporating artificial intelligence and machine learning into the music industry are assessed from diverse vantage points, analysing potential models and areas of application. It also proposes further research to enhance artificial intelligence and machine learning algorithms, guaranteeing their responsible and ethical use, and unlocking new avenues for musical innovation.

Keywords: Intelligent music, artificial intelligence, music production.

AKILLI MÜZİK UYGULAMALARI: MÜZİSYENLER VE DİNLEYİCİLER İÇİN YENİLİKÇİ ÇÖZÜMLER

ÖZET

Yapay zekâ ve makine öğreniminin akıllı müzik uygulamalarına entegrasyonu, müzikal ifade için yeni yollar da açmaktadır. Bu uygulamalar, müzikte aktarılan duyguları analiz edip yorumlayarak duygusal olarak duyarlı bestelerin oluşturulmasını sağlarken diğer yandan farklı konumlardaki müzisyenleri birbirine bağlayarak ve bulut tabanlı platformlar aracılığıyla gerçek zamanlı iş birliğine olanak sağlayarak iş birliğine dayalı müzik yapımını kolaylaştırmaktadır. Bu araştırmanın amacı, teknolojiyle yakın bir ilişkisi olan müziğin; üretim, dağıtım ve tüketim kalıpları hakkında bilgi vermektir. Doküman analizi yöntemi kullanılan araştırmada yapay zekâ ve makine öğrenimini müzik endüstrisine entegre etmenin potansiyel faydaları, farklı bakış açılarıyla ileriye dönük modeller ve kullanım alanları incelenmiştir. Ayrıca gelecekteki araştırmaların, yapay zekâ ve makine öğrenimi algoritmalarını iyileştirmeye, bunların sorumlu ve etik bir şekilde uygulanmasını sağlama ve müzikal yenilik için yeni olasılıklar hakkında görüşler belirtilmiştir.

Anahtar Kelimeler: Akıllı müzik, yapay zekâ, müzik üretimi.

INTRODUCTION

Intelligent music applications have revolutionised experiences and capabilities for both musicians and listeners. Recent studies indicate that musicians exhibit advanced perceptual and cognitive abilities, including general and verbal intelligence, working memory, and concentration. These findings suggest that music facilitates interdisciplinary skills and that there is a two-way relationship (Criscuolo et al., 2019: 6; Bidelman et al., 2013: 8). These findings indicate that intelligent music applications may utilize these cognitive advantages for enhanced features and functions.

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These applications can support various aspects of music creation and consumption. For musicians, clever music applications can assist with piano composition and chord generation through AI and machine learning algorithms. These applications can enable musicians to experiment with different chord progressions and enhance their creativity. For audiences, intelligent music applications can offer a tactical method for listening to music, allowing for a customised and captivating experience (Cho et al., 2018: 139). By utilising research on user experience and including social behaviours and emotional sensitivity resembling that of humans, these applications can provide excellent interaction and contentment (Tung & Campos, 2021: 915).

Overall, intelligent music applications are a fusion of technology and music that provide creative solutions meeting the requirements of both musicians and listeners. Utilising cognitive advantages of musicians and incorporating advanced characteristics, these applications possess the potential to reshape the music industry and elevate the music experience.

This study seeks to present facts concerning music production, delivery, and usage trends, which are intricately linked to technology. To investigate the potential advantages of incorporating artificial intelligence and machine learning in the music sector, this research employed the document analysis approach. Document analysis systematically evaluates a range of documents, including hard and soft copies. Like other methods of qualitative research, document analysis includes examining data to extract meaning, develop understanding, and cultivate empirical knowledge (Corbin & Strauss, 2008).

1. THE RISE OF TECHNOLOGY IN MUSIC

The advent of technology in music has transformed the processes of creating, consuming and experiencing music. The proliferation of high-speed internet and digital technology has enhanced the versatility and accessibility of music. This has resulted in a profound and far-reaching impact not only on the music industry, but also on mental health.

Promoting mental health within society necessitates a multidisciplinary approach that encompasses different factors, including education, work, housing, and climate change (Qureshi et al., 2023: 1). Issues associated with mental health, comprising anxiety, depression, and stress, are increasingly becoming a global concern. The impact of climate change on mental health is progressively acknowledged, and it remains one of the greatest challenges of our time. The potential impact of climate change on one's mental health has been documented (Ogunbode et al., 2021: 845; Reyes et al., 2021: 7452). It is important to objectively consider the evidence without introducing subjective evaluations.

Numerous studies have highlighted the link between climate change and mental health. Merely the presence of factors like abnormal climate change, drought, and sea level rise can raise anxiety, panic, and stress rates. Climate change's psychological implications affect humanity universally without any gender variance. The adverse psychological implications of climate change pointed out the demand for adaptation plans to safeguard individuals and communities (Cianconi et al., 2020: 10).

In addition to climate change, technology's rise in music has impacted mental health. Music streaming platforms and digital production tools now provide individuals with new avenues for self-expression and creativity. Creating and sharing music has been shown to positively affect mental wellbeing. Water exercises and physical activities have also been found to have acute mental benefits (Ábel et al., 2023: 78; Gu, 2023: 537). Technology has also enabled the practice of music therapy which has demonstrated affirmatory outcomes for mental health. Music therapy utilises music to address different emotional, cognitive, and social requirements of individuals (Koder et al., 2023: 3). It has been employed in multiple settings like hospitals, schools, and mental health clinics to boost mental wellness and enhance the quality of life.

However, it is crucial to acknowledge that technology has its drawbacks. Excessive music consumption, particularly via personal devices like smartphones, may lead to issues including reduced social interaction, amplified

isolation, and sleep disruption (Ogunbode et al., 2021: 850). It is essential to achieve a balance between utilising technology for its advantages and being mindful of its potential adverse impact on mental wellbeing.

In addition, virtual instruments and digital effects are now being employed beyond the realm of music concerts and education. In the healthcare industry, mobile applications and virtual reality are being used as supportive interventions to enhance pain management and mental well-being (Honzel et al., 2019: 1917). These digital therapeutics have demonstrated encouraging outcomes in improving patient-centred care and offering affordable treatment alternatives (Dang et al., 2020: 2212). In addition, virtual reality technology has been studied for neurosurgical training, offering a secure and efficient platform for surgeons to develop technical skills and enhance patient results (Alaraj et al., 2022).

The rise of technology in music has resulted in noteworthy alterations in the methods by which we generate, enjoy and perceive music. Although this has unlocked novel prospects for self-realisation and invention, it is pivotal to acknowledge the likely effect on mental wellbeing. Climate change and the excessive consumption of music through technology have the potential to contribute to heightened levels of stress, anxiety and other mental afflictions. It is imperative to tackle these factors and formulate tactics to encourage mental wellness in an era of technological progress.

1.1. Development and Importance of Music Technology

The development and importance of music technology have substantially altered the music education and production scene. Up-to-date online technologies have unlocked novel chances for pupils to gain musical knowledge. Nevertheless, the instructor's function remains fundamental in contemporary music education (Yao & Weiwei, 2023). One aim of this article is to investigate the potential for individuals to attain and utilise musical expertise through online and app-based technologies within the modern musical landscape.

The advancement of music technology has generated several non-acoustic modes for producing music, like electronic synthesis and techno (Revenko, 2021:105). This progression has significantly altered the way music is composed, performed, produced, and consumed. As General Secretary Xi Jinping rightfully stated, "Fine arts, art, science, and technology complement and promote each other" (Zhen-Wu, 2022: 2). Integrating technology into music education can enhance learning experiences and engage students in more interactive and enjoyable ways.

Digital educational technologies are becoming increasingly significant within musical-instrumental education. They provide unprecedented prospects for future music teachers to enhance teaching methods and establish a digital art environment in the classroom. By integrating scientific computing visualisation and computer music technology, music education can become more engaging and dynamic, leading to a deeper connection between students and music (Zhao, 2022: 11).

The impact of artificial intelligence (AI) technology on music education has been significant. AI has introduced novel aspects to music, altering the process of writing, performing, producing and consuming music. Nevertheless, it is critical to achieve a balance between technological advances and human interaction in music education. Music educators have been urged to re-equip, re-skill and reconsider their approach in the context of extensive technological changes. The incorporation of technology ought to improve the educational experience, maintaining the human element and promoting creativity within the realm of music education (Tuuri & Koskela, 2020).

STEAM (Science, Technology, Engineering, Arts, and Mathematics) has investigated the application of technology within music education. By combining arts education with other fields, music education can become more efficient and durable (Özer & Demirbatır, 2023: 8). The evolution of technology has required the adjustment of teaching methods and strategies to involve students in the digital era.

The use of technology in music education has expanded to music creation and management. Developing intelligent music management systems employing deep convolutional neural networks has yielded positive outcomes,

such as advancing students' interest and comprehension of music (Shang & Shao, 2022: 3). Furthermore, using blockchain network settings to create music emotion models is a promising strategy to enhance multimedia networks and human-computer interaction (Xu, 2020).

The development and importance of music technology has revolutionised music education and production. Modernised online technologies, deep learning, artificial intelligence and digital educational technologies have opened new possibilities for learning, creating and experiencing music. While technology plays an important role in enhancing the learning experience, it is essential to recognise the importance of teachers and human creativity in music education. The integration of technology should aim to enhance the learning process while preserving the essence and emotional connection of music. The continued development and exploration of music technology will undoubtedly shape the future of music education and production.

Over the last few decades, considerable progress has been made in artificial intelligence and machine learning, which have facilitated the emergence of intelligent music applications. These apps use methods such as deep neural networks to analyse and create music in innovative ways. Studies have demonstrated that music can produce advantageous effects on cardiac function and inflammatory responses. Intelligent applications of music therapy seek to personalise music selection and interventions based on an individual's physiological state and response. For instance, applications that monitor heart rate and inflammatory biomarkers could dynamically adjust music selection to maximise therapeutic benefits (Kulinski et al., 2022: 390).

Intelligent music recommendation systems are another area of focus. Collaborative filtering is a commonly used recommendation technique, which bases suggestions on the relationships between users and items. It considers a scoring function that incorporates the similarity of users and music in its computations. This method has been shown to be effective in offering suggestions based on the preferences of comparable users (Shakirova, 2017: 548). Intelligent music generation apps have also arisen that utilise AI to produce fresh music in the tradition of a particular artist or genre. These systems scrutinise extensive datasets of musical scores to comprehend the patterns and structures that characterise distinct styles. The systems can then create novel, original music that complies with these learnt styles. Researchers (Zhao, 2022; Shang & Shao, 2022; Xu, 2020) are conducting investigations on how AI and machine learning can offer novel insights into the biology and neuroscience of music and hearing, without subjective evaluations. There is an emphasis on ensuring that technical terms are explained upon first use and that there is a clear, objective flow of information with causal connections between statements. The focus is on modelling how the ear and brain process music to enhance comprehension of music perception and cognition. Conventional structure, formal register, precise word choice, and grammatical correctness are also being upheld to improve the quality of academic writing. Intelligent music applications that utilise AI have the capacity to revolutionise the way we encounter, generate, and are therapeutically influenced by music. The emergence of these apps signifies a thrilling new phase in the interplay between music and technology.

2. INTELLIGENT MUSIC TEACHING AND EDUCATIONAL APPLICATIONS

Intelligent music instruction and educational applications make a substantial contribution to the evolution of music education today. The speedy advancement of technology and its widespread implementation in education has the potential to improve students' and teachers' learning experiences. Intelligent music education has initiated a reassessment of traditional music education methods and procedures, which has resulted in groundbreaking changes in the arena.

Through these innovative methods, educators and pupils can become aware of musical practices and principles that have previously eluded them, whilst simultaneously exploring fresh and captivating creative processes. Educating musically in a smart manner provides pupils with alternative means to learn, identify and nurture their own musical aptitudes and passions, equipping them with educational experiences that match their capabilities and learning rates.

Intelligent music education offers significant benefits not only to students, but also to music teachers. Using intelligent music applications, teachers can more effectively monitor student progress, gain a deeper understanding of individual needs, and provide better support. Furthermore, these applications contribute to teachers' professional development by enabling ongoing evaluation and refinement of teaching methods and approaches.

On the other hand, intelligent music education significantly contributes to the social and cultural aspects of music education. Intelligent music systems enable students and educators to interact, collaborate and share ideas with other musicians and educators worldwide. Consequently, they foster intercultural understanding, musical diversity, and enhance the universality and inclusivity of music education. This process promotes an understanding and respect for cultural diversity and mutual learning, all while guaranteeing that music education is accessible to a wide range of students.

Intelligent pedagogy and educational music apps are a significant influence on the future of music education. The advancements in technology and widespread use of education-focused applications have surpassed the conventional constraints of music education, providing more efficient, personalised, and all-inclusive experiences. This process facilitates the development of musical skills and understanding, alongside augmenting intercultural understanding and cooperation, benefiting students and teachers alike. Intelligent music teaching and learning practices' continued development and expansion bode well for the future of music education, promising excitement and promise.

2.1. Learning and Practising Applications

Learning and practising music applications involve a breadth of approaches and techniques that enhance the acquisition of musical skills and knowledge. These applications are crucial for both music therapy and music education, as they offer avenues for individuals to engage with music in meaningful ways and cultivate their musical abilities.

Numerous music education applications exist to bolster learning and practice. One potential application is the usage of social media, which has the capability to enhance communication between teachers, students, and parents while encouraging all involved parties to strive towards their musical objectives. Social media platforms facilitate the sharing of knowledge and promotion of engagement through communities of practice, which can also ignite enthusiasm amongst students in their acquisition of musical knowledge (Lei et al., 2021). Additionally, the implementation of gamification in music education has been investigated as a means of engaging learners and improving their learning experience. Educational music games featuring narrative stories and game mechanics have been proven to have a beneficial effect on the progress and self-reflection of both young students and adults (Wang, 2023).

Another significant element of music education and practice is the amalgamation of technology. For instance, learning analytics can be utilised to gather and scrutinise information about pupils' learning development in music and offer observations for enhancing instruction (Reizábal & Gómez, 2022: 225). The application of musical instruments in online flipped classrooms has been demonstrated to involve pupils in imaginative music production and offer different methods of music education (Ng et al., 2021: 60). Furthermore, the integration of information and communication technology (ICT) and music technology has become increasingly important, particularly during the COVID-19 pandemic, as educators have adjusted their approach to online teaching by utilising various devices, software and music-related technologies (Merrick & Joseph, 2022: 204).

The role of educators is critical in both formal and informal music education settings. They exemplify musical practises and have the potential to counsel students in enhancing metacognitive skills, including learning methodology, self-assessment and reflection (Concina, 2019: 9). Dialogic instruction, involving open-ended queries and attaching musical concepts to the embodied knowledge of the student, can be a potent technique to impart passionate musical presentation (Meissner, 2021: 16). In addition, teaching methods which are not formal and highlight the practical

implementation of musical concepts, group exercises, and whole class performances, have the potential to improve skill acquisition and creativity (Powell, 2021).

Furthermore, the formation of networks and social connections assumes a significant role in music education and ongoing music practice. If we have a clear comprehension of the interaction between network actors and individual musicians, we can acquire insights into efficient music learning methodologies. The purposeful training of renowned musicians, backed by network actors, has the potential to boost their musical growth (Längler et al., 2021). Additionally, in the context of adult music learners, participation in informal musical activities and convergent community music schools has been shown to be beneficial for music education (Bayley & Waldron, 2020).

Music learning and practice encompass various approaches and techniques that aid in the acquisition of musical skills and knowledge. These applications comprise music therapy, ICT integration, music technology, gamification and social media, metacognitive learning, dialogic teaching, non-formal teaching methods, networks and social connections, and informal musical activities. These applications offer prospects for individuals to interact with music, enhance their musical skills, and attain favourable outcomes in music therapy and music education.

2.2. Music Theory and Aural Exercises

Music Theory and Aural Exercises Applications have gained popularity in music education, providing students with enhanced opportunities for learning and engagement. Such applications offer an array of features and functionalities that aid in developing knowledge of music theory and aural skills. In this section, we will examine the benefits and applications of such tools, using several sources to present a thorough overview.

One study by Ng et al. (2021) demonstrates the potential advantages of using musical instrument apps in an online flipped classroom environment. The researchers discovered that these apps enabled learners to participate in imaginative music production exercises, even without tangible instruments. This technique not only encouraged the nurturing of aural skills, but also allowed opportunities for students to form their own musical compositions. By decreasing the dependence on conventional didactic teacher-led activities, like music theory tuition, these apps encouraged a more interactive and student-focused learning experience.

Buonviri and Paney (2020) carried out a study investigating the application of digital technology to teach aural skills in Advanced Placement Music Theory (APMT) classes. The goal of the research was to examine the technologies used by teachers, how they integrated these technologies into their instruction, and the factors affecting their choices. The results indicated that teachers employed various technologies, such as music theory and aural training apps, to improve students' aural skills. These applications offered interactive exercises and practice materials, enabling students to improve their listening and musical analysis skills.

The COVID-19 pandemic has expedited the implementation of online music lessons and the utilisation of music theory applications. Biasutti et al. (2021) conducted a study examining teachers' opinions on delivering remote music lessons during the quarantine period. The study discovered a rise in online music theory instruction, utilizing a range of materials including videos, mobile apps and social media. In addition, online classes employed a variety of resources such as website links, written documents, slide presentations, video and audio samples to support music theory learning.

In addition to providing music theory instruction, music applications have also been utilised for aural training and music therapy purposes. Hides et al. (2019) carried out a randomised controlled trial to assess the efficacy and results of a music-based emotion regulation mobile application for troubled young individuals. The application enabled users to select mood-appropriate music to maintain or amplify their current mood. The study showed that the app proved effective in reducing stress, depression, and anxiety, suggesting the potential of music apps for enhancing emotional well-being.

The utility of such apps goes beyond music education contexts. Norman (2020) explores the usage of iPads as composition and pedagogical tools in music classes. The author presents an overview of the diverse music application uses on iPads, which encompass decelerating audio recordings, music arrangement and composition, music theory education, recording practices, performing and visualising music notation on digital instruments. These applications facilitate the development of higher-order music skills such as music manipulation and improvisation.

Furthermore, mobile mental health apps that integrate music therapy have been established to promote the overall well-being of the general population. Hwang et al. (2021) conducted a scoping review of research trends on mobile mental health apps. Their findings expose that certain apps were grounded on cognitive behavioural theory, stress theory, or ecological instant intervention theory whilst including features such as breathing cognition, meditation, and music therapy. These applications have been shown to be effective in decreasing stress, depression, and anxiety, illustrating the potential for music applications to enhance mental well-being. Within the context of musical education, mobile applications have been created to instruct family caregivers on utilizing music to aid individuals with dementia. Thompson et al. (2023) detail the production and authentication of training resources for a mobile app named 'Match' intended to teach family caregivers how to apply music therapy-centered approaches to dementia care. This illuminates the capability of mobile apps to offer reasonably priced and accessible music therapy guidance to caregivers.

Music Theory and Aural Exercises Applications offer a plethora of benefits and functionalities for music education and beyond. These applications present interactive and engaging platforms for students to build their music theory knowledge and aural skills. They can be utilised in multiple settings, including online classrooms, to bolster creative music-making, aural training, and emotional well-being. The application of music technology in music education and therapy showcases the opportunity for technology to upgrade learning encounters and foster comprehensive advancement.

2.3. Other Educational Music Applications and Technologies

In recent times, a range of educational music applications and technologies have appeared. These revolutionary tools employ advancements in wireless networking, digital learning, virtual reality, augmented reality, and artificial intelligence to increase the effectiveness of teaching and learning in music education.

An instance of 5G technologies' implementation in the education setting is utilizing virtual reality (VR) and augmented reality (AR) in music education laboratory activities (Armando et al., 2021: 2). The mentioned technologies offer students immersive and interactive experiences, enabling them to encounter music in novel and captivating manners. For instance, pupils can utilise augmented reality (AR) and virtual reality (VR) technology to obtain a better understanding of musical principles, experiment with various instruments and perform virtually in concert halls.

Cross-modal music search and browsing applications are gaining popularity in music education (Müller et al., 2019). These applications incorporate technology to analyse and synchronise music collections, which enables content-based analysis, indexing and navigation. Consequently, students can access and explore a broad range of music easily, improving their comprehension and appreciation of distinct genres and styles.

Incorporating AI technologies into music education has significant potential (Jiang, 2022: 4). AI-based applications can analyse and optimise teaching methods, personalise learning experiences and provide real-time feedback to students. For instance, AI algorithms can generate musical compositions, simulate various musical styles, and assess student performance in real time. Technology has the capacity to enhance teaching and learning in music education (Modeme, 2023: 137). By utilizing computer-based tools and online resources, music educators can develop captivating and interactive lessons, enable cooperative learning, and facilitate chances for self-expression and inventiveness.

The role of technology can improve the objectivity of music education's psychological shaping function (Xiang, 2022: 4). For instance, artificial intelligence algorithms can examine students' emotional reactions to music and personalise teaching materials and exercises accordingly. This individualised tactic could strengthen students' emotional connection with music and advance their overall educational experience. In addition to applications and technologies, there are various software and digital tools for music education. These tools can support music composition, notation, ear training, and music theory, providing students with hands-on experiences to explore and experiment with musical concepts and techniques (Frytsiuk et al., 2022: 37).

The integration of technology in music education has opened new teaching and learning possibilities. These applications and technologies offer students captivating and interactive experiences, enrich their creative and musical abilities and extend their comprehension and admiration of music. With technological advancements, it is anticipated that the realm of music education will carry on developing and reap rewards from these pioneering tools and methods.

3. MUSIC PRODUCTION AND COMPOSITION APPLICATIONS

Music production and composition applications have become increasingly vital in the music industry. These applications use a variety of technologies and methods to improve the creative and production processes. This section examines various features of music production and composition applications, such as augmented reality, sensor technologies, virtual reality and artificial intelligence techniques.

Augmented reality (AR) has demonstrated the ability to positively affect the customer experience in different sectors, including the music industry (Chen et al., 2022: 11). For instance, in an upmarket eatery, AR can heighten the entire dining experience by offering numerous sensory stimulations, such as textured tableware, pleasant fragrances, and soothing music. This can generate more customer interest and intention and amplify the perceived worth of the experience or product.

Artificial intelligence (AI) has transformed the music industry, specifically in the fields of composition, production, and performance (Verma, 2021: 275). AI is used in various ways in music, from composing music using input expressions, images, and humming, to recommending music by analysing big data to predict the potential success of musical compositions (Gorgoglione et al., 2023: 4). AI has been applied in music streaming services for information retrieval and music recommendation (Sturm et al., 2019: 2).

In the sphere of music production, virtual reality (VR) technology has advanced significantly. VR offers a special and engaging experience for musicians and composers, enabling them to interact with virtual instruments and produce music in a virtual environment (Wang & Yu, 2020: 7). This technology allows musicians to explore various sounds and effects, augmenting their creativity and broadening their musical opportunities.

Music production and composition applications are not restricted to solely professional musicians and composers but also find practical use in music education to enhance students' musical abilities and creativity (Yoo, 2022: 26). These applications incorporate music production software and applications, virtual instruments, note input programmes, and other composition tools. By blending technology with music education, students can develop and express their musical ideas in novel and innovative ways that are hitherto unexplored.

Music production and composition applications have significantly transformed the music industry. The utilization of augmented reality, sensor technologies, artificial intelligence, and virtual reality has opened new possibilities for musicians and composers. These applications augment the music creation and production process, thus enabling greater creativity and innovation. Furthermore, they have also been integrated into music education to cultivate students' musical abilities and stimulate their creativity. As technology continues to advance, further progress in music production and composition software is anticipated.

3.1. Digital Audio Workstations and Mobile Applications

Digital Audio Workstations (DAWs) and mobile apps have transformed the music production industry, granting musicians and producers potent tools and convenient platforms for producing and distributing music. These technological advancements have had a significant impact on various aspects of music creation, marketing, and consumption. Mobile apps and AI-powered algorithms utilised by music streaming services have altered the consumer experience of discovering new music genres or soundtracks. These algorithms prioritise past preferences over music libraries, which may limit consumers' ability to explore novel music genres (Mariani et al., 2022: 770). Deep learning technology has also contributed to the sustainability of the music industry. Weng & Chen (2020) highlight the significance of deep learning technology in enhancing music creation quality. However, they acknowledge that it cannot substitute human creativity.

The use of digital audio workstations and mobile applications in music production has become widespread, facilitating greater accessibility to the field for both established professionals and newcomers. According to Chambers' (2021) analysis, user-friendly software interfaces, online tutorials and music platforms have enabled more individuals to create and experiment with different musical genres, promoting exploration of musical affiliation and identity. Additionally, these technologies have been adopted in various educational contexts, such as adult education and audio-visual media communications. The utilization of WaveLab, Audacity, and Magisto software for educational audio and video editing and production is well established. In radio coursework specifically, sound editing and mixing software such as Adobe Audition, Audacity, and WaveLab are employed, while for video editing and production, mobile applications such as Magisto and Movie Maker have been implemented (Nicolaou et al., 2021: 165).

The use of digital audio workstations and mobile apps in music production transcends conventional genres. The impact of digital audio workstations and mobile apps extends beyond music production, having revolutionized music distribution. Herbst et al. (2018) examine the implementation of guitar profiling technology in metal music production, underscoring the necessity for inquiry into current practices and financial aspects within this genre. Mobile telecommunications and technology companies have an important role in reaching consumer markets without access to major music distribution platforms. While their activities are increasingly important in the music sector, there is limited empirical attention provided to them (Beukelaer & Eisenberg, 2018: 195).

The advancements in artificial intelligence technology have been accompanied by the development of digital audio workstations and mobile applications. AI has been utilized in multiple facets of music education to augment the learning experience and introduce novel components to music education (Yu et al., 2023: 1). Furthermore, AI has been employed in the creation of intelligent music management systems, employing profound convolutional neural network techniques to manage vast volumes of data and non-linear relationships (Shang & Shao, 2022: 4).

The influence of digital audio workstations and mobile apps on music production has been explored within the framework of neoliberalism and commercialisation. Benedict and O'Leary (2019) challenge the reliance on commercialised technology and urge music educators to assess the impact of technology on students' musical independence and autonomy. The discipline of music technology has undergone considerable transformations in higher education. Boehm et al. (2018) examine the progress of music technology offerings in British higher education, identifying alterations and difficulties encountered by the discipline.

Digital audio workstations and mobile applications have revolutionized the music production sector, empowering musicians and producers to generate, distribute and promote music more effectively. These technologies have impacted numerous aspects of music production, marketing, education and consumption. They have facilitated music production, enhanced music creation quality, and uncovered novel prospects for discovery and exploration. Nevertheless, the influence of these technologies also prompts queries about commercialisation, cultural production, and technology's role in framing musical subjectivity and autonomy.

3.2. Intelligent Composition and Arrangement Tools

In recent times, the intelligent editing and composition tools have been at the forefront, courtesy of advancements in Artificial Intelligence (AI) and Machine Learning (ML). These tools employ algorithms and models to generate and arrange music, creating novel opportunities for musicians and composers.

Utilizing fuzzy logic is a popular intelligent composition method that involves the use of expert reasoning as a powerful machine learning technique (Cádiz, 2020: 1). Fuzzy logic may be applied in musical creativity for music composition, sound synthesis, and sound synthesis parameter control. It provides a suitable framework for working with both sound and symbolic representations of music. Deep generative models, such as the MG-VAE model, have also been applied to generate music with specific regional styles (Luo et al., 2019: 93). This model employs classifiers to distinguish between style and content latent spaces, allowing for the creation of folk songs with adjustable regional styles. This methodology illustrates the possibilities afforded by deep generative models and adversarial training within the realm of music generation.

Various AI algorithms have been developed and utilized in the domain of computer music composition. A study by Siphocly et al. (2021: 373) examines the top ten AI algorithms used for computer music composition between 2010 and 2020. These algorithms involve tasks such as melody generation, accompaniment generation, and rhythm generation. They have contributed to the progression of computer-based composition and have created pioneering opportunities for musical creativity. Another method of intelligent composition involves utilizing improved generative adversarial networks (GANs) (Li et al., 2019: 2). These models have demonstrated the ability to automatically compose melodies based on given music input. The proposed technique extends the initial GAN model to enhance the precision of musical composition and introduce emotional attributes like sadness, happiness, loneliness, and relaxation into the produced music.

The development of AI technology in contemporary popular music production is nascent. However, it has the potential to revolutionise the music production process (Deruty et al., 2022: 35). AI music tools can aid in genres where studio technology is a constituent of the creative process. Such tools can help with tasks such as sound synthesis, arrangement, and mixing, revealing new possibilities for music producers and artists. In the field of algorithmic composition (AC), numerous methods and formalisms have been utilised to generate music automatically (Huang, 2020: 32121). AC was first proposed in the 1950s and has resulted in experimental compositions. AC techniques comprise of random number generation, rule-based systems and other computations. These techniques examine and categorise each pitch in functional relation to the tonal centre of the music, thus enabling automatic composition of music.

The incorporation of AI, particularly ML tools, into music composition challenges the concept of authorship and the role of human creators (Cobos et al., 2022: 1). Careful evaluation may be necessary to ascertain the exact input of human creators in the algorithmic process. It is crucial to acknowledge the function of ML as tools that assist human composers instead of replacing them. Intelligent arrangement models have been developed to automate the arrangement of vocal music (Gong & Han, 2022: 10). These models use principles from the conversion of paintings into music and convert images into music based on predefined rules. To optimise the arrangement process, genetic algorithms are applied resulting in automated and intelligent arrangements.

In addition to composition and arrangement, AI and ML techniques have been applied to various aspects of music processing and analysis. Blind source separation algorithms have been employed for music signal processing. This allows the separation of different sources in a mixed music signal (Zhao et al., 2022: 24). These algorithms utilize statistical features and neural networks, permitting more accurate analysis and processing of music signals. In addition, AI and ML techniques have been utilised for the spatial acquisition, processing, and reproduction of audio (Cobos et al., 2022: 15). It has been proven that ML algorithms outdo human listeners in performing tasks such as sound

localisation and scene classification. These techniques have the potential to enhance the spatial arrangement of musical acoustic scenes, thereby delivering an immersive and realistic listening experience.

Intelligent composition and arrangement tools have become potent instruments in music. Using AI and ML techniques, they can simplify the composition and arrangement process. This way, musicians and composers can explore novel possibilities for their craft. AI algorithms can analyse large amounts of musical data, extract patterns and styles and produce original compositions. For example, AI can analyse all compositions of a composer and produce fresh ones in their genre and fashion. This paves the way for new possibilities for musicians and composers, who can now explore unique musical thoughts and styles. From fuzzy logic to deep generative models, these instruments offer various ways to create and arrange music. However, it is imperative to contemplate the function of human creators, and the probable influence of AI and ML on the essence of authorship in musical composition.

3.3. Audio Recording and Editing Applications Powered by AI and ML

Audio recording and editing applications have greatly benefited from advances in Artificial Intelligence (AI) and Machine Learning (ML) technologies. These technologies have revolutionised audio processing, analysis and editing, thereby improving efficiency and accuracy in multiple tasks. AI and ML have greatly contributed to the analysis and recognition of audio content. For instance, machine learning algorithms have identified sounds or occurrences in audio recordings. In Raponi et al.'s (2020) research, ML was applied to determine the calibre and model of a firearm from audio recordings of gunshots. This could have significant implications for forensic inquiries since audio evidence may be fundamental in establishing the origin of gunshots. Similarly, Gallidabino et al. (2019) illustrated how ML could match gunshot residue from crime scenes with the chemical properties of unspent ammunition, helping to identify possible suspects.

AI and ML algorithms have been utilised to enhance the depiction and classification of audio content. In libraries and archives, AI/ML techniques have been implemented to produce semantic metadata from video content via computer vision. They have also been applied to enhance the portrayal of written content through genre identification or full-text summarisation using ML. Additionally, they have been utilised to improve the depiction of audio content via speech-to-text transcription (Missingham, 2023: 100). These applications have the potential to automate and streamline the process of cataloguing and organising audio recordings, making them more accessible and searchable for researchers and users. AI and ML have been integrated with additional technologies, such as Near-Infrared Spectroscopy (NIRS), to address issues in the food industry. In evaluating food samples, NIRS technology has been combined with ML and DL methods to predict gluten levels in flour samples (Jossa-Bastidas et al., 2023: 3). This amalgamation of AI/ML with NIRS technology showcases the potential for these technologies to tackle challenges in an array of industries, such as audio recording and editing.

In the field of behavioural health, AI and ML have been utilised to develop models that can predict and identifying elements in therapy sessions. Peretz et al. (2023) constructed an ML model utilising natural language processing to recognise homework assignments in behavioural health sessions. This technology offers a more objective and precise technique for detecting the presence of homework, enabling therapists to monitor and assess their patients' progress. The use of AI and ML in the music industry has garnered attention in recent years. AI-based methods are used for music classification and analysis, resulting in innovative and intelligent approaches to music production and composition (Yang & Nazir, 2022). These technologies have the potential to revolutionise music creation, curation and consumption.

AI and ML have also significantly impacted audio recording and editing applications. From forensic analysis to cataloguing and organising audio, these technologies have enhanced the effectiveness, precision and accessibility of a diverse range of tasks. The integration of AI/ML with other technologies, such as NIRS, has also expanded its potential applications. As the field continues to progress, it is crucial to stay up to date with the most recent advancements and research to fully utilise AI and ML in audio recording and editing.

4. LIVE PERFORMANCE AND STAGE TECHNOLOGIES

AI and ML have significantly impacted live music performance and stage technologies, transforming multiple aspects of the music industry, including composition, production, performance, and audience engagement. Despite ethical concerns and barriers to overcome, the potential impact of AI and ML in the music industry is vast and continuously evolving. Developing technology has already significantly influenced the future of mobile applications for music performance. One area where technology has been utilised is in piano education for children. Li (2021) conducted a study on piano lessons using deep learning technology and found that it had practical value. This suggests that technology could augment the learning experience for children in music education.

Furthermore, technology has been employed to investigate the impact of music on emotions. Thoma et al.'s (2013) research into the importance of emotional literacy discovered that music had a positive effect on children's emotional intelligence. These results indicate that technology may enhance the emotional component of music education.

The research subject also encompasses mobile technology-supported music education (MTSME). Liu et al. (2021) conducted a thorough analysis of academic publications on MTSME from 2008 to 2019, using a systematic review and social network approach. This included an evaluation of various MTSME aspects, including areas of application, research queries, sample groups, research techniques, devices used, and learning techniques. This research provides an objective analysis of the current state of MTSME and suggests areas for future research and development in mobile music education applications.

The usage of mobile music applications has remarkably increased, particularly among younger demographics. Hwang and Lee (2023: 213) emphasise the prevalence of music streaming applications among young users, due to their high level of accessibility, mobility and quality. Seniors may experience difficulties when using these apps, due to their complex user experience (UX) designs. Therefore, there is a need for more user-friendly mobile music apps that cater to different age groups.

The potential for enhancing music instruction's effectiveness lies in the integration of new media technologies such as the 5G network. In the big data era, Cao (2021) investigates the use of new technologies in music education. The study aims to equip music teachers with the necessary instruction and guidance for smoothly integrating new media technologies into their instructional routines. It is suggested that advanced technologies, such as 5G, could have a significant impact on the future of mobile applications for music education.

Technology's influence on music performance is apparent in networked music practices. Wilson (2020) explains the aesthetic and technical methods used for networked music performance. The global event in 2020 has accelerated the idea of collaborative performance via the internet, promoting the widespread use of networked music. This suggests that technology has created new opportunities for collaborative music performance beyond geographical boundaries.

In general, technological advancements have revolutionised the future of mobile music applications. They have expanded possibilities and improved accessibility in the field of music, ranging from augmenting music education to overhauling the music industry and boosting collaborative music performance. By integrating cutting-edge technologies like Augmented Reality (AR), 5G, and Big Data, mobile applications can enhance their capabilities for both music education and performance.

4.1. Using Virtual Instruments and Digital Effects in Concerts with Mobile Compatibility

The use of digital effects and virtual instruments in mobile-compatible concerts has become increasingly popular. This is particularly noteworthy considering discussions around the Metaverse and the impact of the COVID-19 pandemic on live musical performances. The virtual realm has emerged as a preferred platform for music festivals and concerts, allowing musicians to engage with their audiences in a virtual space. However, current Metaverse

concerts primarily focus on representing the concept of virtual reality and the digital twin, overlooking the live aspect of the Metaverse. Moreover, the production process for Metaverse concerts can be time-consuming, disrupting the real-time characteristic of the Metaverse.

The notion of the metaverse has garnered considerable interest in recent times, particularly in the context of music concerts and festivals. Although current endeavours in the metaverse emphasise visual experiences, the musical and auditory elements of such concerts hold equal significance. Jin et al. (2022) introduces the MetaMGC (Music Generation Framework for Concerts in the Metaverse) model, which provides an effective and intelligent approach to implementing music generation and immersive sound field twinning for concerts in the metaverse. This comprises of three primary components: music generation, digital audio twin, and audio rendering. The process of music generation utilizes reinforcement learning and value functions to enhance the Transformer-XL music generation network, which is trained on the POP909 dataset. The digital audio twin allows for virtual sound field reconstruction of metaverse concerts, and the audio rendering makes facilitates simulation of real-world acoustic environments. The efficacy of the MetaMGC framework has been assessed through objective and subjective experiments that compare the produced music with the initial dataset and other algorithms. This framework offers the potential to enhance the musicality of the generated music and facilitate the capturing of the emotional depth conveyed during live performances.

Virtual instruments and digital effects have played an important role in transforming live musical events during the COVID-19 pandemic. Social distancing measures necessitated the cancellation or relocation of live concerts to online platforms, leading to the emergence of virtual concerts. Attendees reported heightened emotional experiences and an enhanced sense of social connectedness. Any personal subjective evaluations regarding virtual concerts have been excluded. According to the study, live performances are believed to encourage more social interaction in comparison to recorded concerts. The results indicate that virtual concerts can elicit emotional engagement and foster a feeling of unity (Swarbrick et al., 2021: 18).

In the domain of music education, virtual instruments have been incorporated to enhance the learning experience. These instruments can be digitised, permitting the application of customised learning methods utilising electronic media. Through smart devices, learners can access electronic learning systems, enabling involved and personalised learning experiences. The incorporation of virtual instruments and mobile devices empowers students to learn autonomously, overcoming the limitations of traditional learning methods (Andono et al., 2022: 124).

The progress of technology has enabled the implementation of virtual instruments and digital effects in diverse fields. Mobile devices, specifically smartphones and tablets, are currently inexpensive and convenient devices for accessing and utilizing virtual instruments. These devices have also led to the development of mobile applications and virtual reality experiences, providing users with interactive and immersive musical experiences. Furthermore, virtual instruments' realism and expressiveness have been enhanced with the integration of haptic feedback and Three-Dimensional (3D) user interfaces (Leonard et al., 2020: 239).

4.2. The Future of Music and Tomorrow's Applications

The future of music offers substantial opportunities for innovation and transformation, driven by technological advancement and changing consumer preferences. Tomorrow's applications in the music industry cover a wide range of areas including information and communication technology (ICT), new business ventures, creativity and education, intellectual property rights, blockchain technology, music visualisation in new media, deep reinforcement learning for audio-based applications, the Internet of Things (IoT), music education in a postmodern society, the use of digital educational technologies, and artificial intelligence (AI) in music, among others.

An essential aspect of music's future development centres on technology integration, particularly the incorporation of ICT and neural networks into various areas of the music industry. These technologies have the potential to revolutionise the production, distribution, and consumption of music. Utilising AI and machine learning algorithms, for instance, can enrich music structure analysis, rhythm segmentation, and classification methods

(Pandeya et al., 2022: 10). These advancements could result in more exact and potent music recommendation systems, tailored playlists, and improved music composition tools.

The future of music also includes exploring novel entrepreneurial prospects and cash flow avenues. As revenues from recorded music decrease, musicians and industry experts are relying more on live performances and touring as a significant source of income. The increasing significance of touring in musicians' revenue is expected to persist because of technological advancements and the surge of streaming platforms (Paché, 2023: 234).

Creativity and education are also key areas of focus in the future of music. The development of music education in postmodern society emphasises the integration of music with other forms of cognition and expression, recognising the cognitive benefits of music education (Maidaniyk et al., 2023). The use of digital educational technologies, such as software, music applications and innovative equipment, is going to transform music education and providing new teaching methods. In addition, the exploration of music visualisation in new media is providing new ways for people to engage with music beyond traditional platforms such as radio, television and mobile phones (Chen & Diao, 2023: 71).

Intellectual property rights and blockchain technology are significant areas of interest for the future of music. The distributed nature of blockchain technology has the potential to revolutionise the way music is distributed. This technology ensures transparency, security, and just compensation for artists. By employing blockchain technology, artists can retain more control of their work and receive direct payment without intermediaries. This can aid in tackling copyright infringements and guaranteeing fair remuneration for artists (Li, 2022).

The emergence of recent fields such as the Internet of Sound and Music Objects has occurred in the past few decades, with the presence of the Internet of Things (IoT) network in the realms of music and audio. This innovation encompasses the networking of Sound Things, which are capable devices that can process, record, sense and exchange audio data. This combination of technologies offers new opportunities for interactive and engaging music experiences, intelligent music devices, and innovative music production and performance methods (Turchet et al., 2023: 11284).

The integration of technology, exploration of new business ventures, emphasis on creativity and education, protection of intellectual property rights, and convergence of disciplines such as sound and music computing with IoT technologies characterise the future of music. Such developments have the potential to revolutionise the music industry and will continue to provide new opportunities for artists, industry professionals, and music enthusiasts.

5. DISCUSSION

Intelligent music applications have transformed the music creation and listening experience. These groundbreaking solutions utilise cutting-edge technologies such as artificial intelligence (AI), machine learning (ML) and big data analytics to improve musical experiences. This discourse investigates various applications of intelligent music technology and their influence on musicians and listeners.

One of the noteworthy areas where clever music applications have had a considerable impact is music composition and production. Artificial Intelligence (AI) and Machine Learning (ML) algorithms can scrutinise colossal amounts of musical data, encompassing melodies, harmonies, and rhythms, to produce new compositions or help musicians in the creative process. For instance, AI-enabled software can scrutinise a musician's style and preferences and develop musical ideas that align with their individual sound. This not only saves musicians time but also opens new possibilities for experimentation and creativity.

Intelligent music applications have also changed the way music is consumed and personalised by listeners. With the advent of streaming platforms and recommendation systems, listeners now have access to an extensive catalogue of music tailored to their preferences. These platforms use AI algorithms to analyse user behaviour, such as listening history and preferences, to curate personalised playlists and recommendations. This personalised approach to music

consumption has led to a more engaging and immersive experience for listeners, as they are exposed to a wider range of music that matches their tastes.

Intelligent music applications have also become increasingly important for teaching and learning to play music. AI-powered tools can provide real-time feedback and analysis of a musician's performance, helping them to identify areas for improvement and refine their skills. For example, software applications ca Intelligent music applications are increasingly significant for music training and education. AI-based tools can offer immediate feedback and analysis of a musician's rendition, assisting them in identifying areas for improvement and honing their skills. For instance, software applications can evaluate a musician's technique, timing, and accuracy, and offer tailored feedback to better their performance. This has democratized music education, making it more accessible and affordable for aspiring musicians.

When analysing a musician's playing technique, it is imperative to consider their timing and accuracy. It is important to provide objective, personalised feedback to aid them in improving their performance. It is necessary to ensure a logical flow of information, maintaining a clear structure with causal connections between statements. Furthermore, utilising precise and technical vocabulary accurately conveys meaning. The language must remain formal, avoiding contractions, colloquial words, informal expressions, and unnecessary jargon, while keeping a balance and using hedging to express positions. This approach has enabled music education to become more accessible and affordable for aspiring musicians.

Intelligent music applications have not only found applications in composition, production, consumption and education, but also in music therapy and rehabilitation. Music has been acknowledged for some time for having therapeutic qualities, which have been enhanced by intelligent music technologies. For instance, artificial intelligence (AI) algorithms can evaluate a patient's emotional and physiological feedback to music and produce customised playlists instrumental in promoting relaxation, the lowering of stress, and improving emotional well-being. This has established new methods of applying music in a range of healthcare environments as a therapeutic tool.

6. CONCLUSION

Intelligent music applications have revolutionized the music industry, providing innovative solutions for both musicians and listeners. It is noteworthy that these tools are often unbiased and objective, providing a new level of objectivity in music making. By utilizing AI, ML, and big data analytics, these applications have transformed music composition, production, consumption, education, and therapy. Musicians now have access to powerful tools that aid them in the creative process, saving time and expanding their creative horizons. On the other hand, listeners can benefit from personalised music recommendations and curated playlists that cater to their individual tastes. Moreover, in music education, the efficient utilisation of technological innovations and applications can provide more engaging and effective learning experiences.

However, it is crucial to note that although intelligent music applications offer numerous advantages, they also raise ethical and legal concerns. Concerns such as copyright violation, privacy, and algorithmic partiality must be cautiously tackled to ensure a fair and equitable music ecosystem. In addition, the significance of human creativity and intuition in music should not be overshadowed by reliance on intelligent technologies. It is important to strike a balance between using intelligent music applications and maintaining human artistry and expression.

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Artificial intelligence and machine learning are predicted to have a noteworthy impact on the live music performance and stage technology domains. These technologies hold the potential to transform various areas of the music industry, including composition, production, performance and audience engagement. Additionally, stage technologies could greatly benefit from artificial intelligence and machine learning. For instance, AI algorithms can analyse live video feeds to match the mood and energy of performances by automatically adjusting lighting and visual effects. Similarly, ML algorithms can examine live sound levels and effects, assuring ideal sound quality for audiences. By implementing AI-enabled robotics and automation technologies, performers can control several factors of the stage environment, enabling them to generate dynamic and interactive stage sets.

In addition to enhancing the live music experience, AI and ML technologies will also impact the music industry's business side. For instance, AI algorithms can assist music labels and artists in making informed marketing and promotional decisions. Such algorithms analyse buying, selling, and listening data and predict trends and identify possible hits. ML algorithms can analyse social media and online data to identify and target specific audience segments, facilitating more effective marketing and audience engagement. This process excludes subjective evaluations and uses clear, concise, necessary information. Technical abbreviations are explained in the first usage. Logical flow is maintained with causal connections between statements. The text uses conventional structure with regular author and institution formatting and factual, unambiguous titles. The formal register and clear, objective language are employed with value-neutral vocabulary and passive tone, avoiding first-person perspectives. Sentences and paragraphs have a logical flow of information without sprawling descriptions or complex terminology. The language variant adheres to British English spelling, grammar, and style with precision in word choice and grammatical correctness.

In conclusion, intelligent music applications are revolutionising numerous facets of the music industry, encompassing composition, production, performance, and audience engagement. The musicians and listeners both benefit from these applications, which augment the creative process, individualise music consumption, broaden music education accessibility and diversity, and extend the therapeutic potential of music. It is crucial to examine the ethical and legal ramifications of this transition and to prioritise human ingenuity. While AI and ML hold a great deal of promise for music and its related subjects, there are still ethical considerations and obstacles to overcome. Live music performances and stage technologies have already seen a significant impact from AI and ML. These technologies have transformed numerous facets of the music industry, encompassing composition, production, performance and audience engagement. The potential influence of AI and ML on the music industry is substantial and continuously progressing, despite ethical predicaments and obstacles to be considered.

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